Test Automation Tool for POLQA® and PESQ® Speech Quality Tests

Application Note

Products:

- R&S®UPV
- R&S®UPV66
- R&S®UPV-K1
- R&S®UPV-K61
- R&S®UPV-K63
- R&S®UPL-Z1
- R&S®CMU200
- R&S®CMW500

This application note provides an application program for level alignment, test automation and reporting with PESQ®, POLQA® and delay measurements on the Audio Analyzer R&S®UPV or R&S®UPV66. An introductory section explains theoretical background, gives application hints and defines requirements for test signals.

ROHDE&SCHWARZ

Application Note

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1 POLQA® and PESQ® Measurements

1.1 Objective Perceptual Speech Test Methods

POLQA® and PESQ® are objective perceptual speech test methods.

A speech test method rates the quality of a speech signal as opposed to a conversational rating where impairments like round-trip delay are judged for their impact on a conversation.

A perceptual test method delivers results which assess degradations the same way as human beings would do. Non-perceptual test methods usually determine physical entities like voltage level.

A possible implementation of a perceptual test is a subjective listening test, e.g. according to ITU-T P.800. In a subjective test, speech signals are presented to subjects under standardized listening conditions (level, playback equipment) with a well-defined judgement task or question. Such a task could be to categorize the quality of a presented speech signal according to the question “how good does the voice sample sound?” into one of five steps between 5 = “Excellent” and 1 = “Bad”. The answers from many subjects are averaged to obtain a so-called “MOS” (Mean Opinion Score).

An objective perceptual speech test method implements a complex algorithm which predicts results expected from subjective tests by applying psychoacoustic and perceptive models to the test signals. The algorithm is verified by comparing the results to MOS scores obtained in subjective listening tests. A mapping function may be applied for better matching between the objective and subjective MOS scores.

PESQ® and POLQA® are so-called full-reference test methods. They analyze the original (“Reference”) speech signal and the degraded signal and compare attributes extracted from both for obtaining an assessment of the degradation.

1.2 Bandwidth and Listening Situation

In telephony different bandwidths are defined:

- Narrowband (300 Hz ~ 3400 Hz)
- Wideband (100 Hz ~ 7 kHz)
- Superwideband (50 Hz ~ 14 kHz)
- Fullband (20 Hz ~ 20 kHz).

PESQ® provides a narrowband and a wideband mode. In both cases listening tests for the verification of the algorithm were performed monaural using a so-called IRS type receiver. The same applies to the POLQA® narrowband mode.

In POLQA® superwideband mode the subjective tests are performed with high-quality stereo headphones. POLQA® does not provide a wideband mode.

ITU-T P.863 mode	Signal bandwidth	Listening situation	Scale	Output
Super-wideband	Superwideband wideband narrowband	Flat headphone diffuse field equalized, diotic presentation	MOS ACR superwideband scale	MOS-LQOsw
Narrowband	Narrowband	IRS receive handset, monotic presentation	Narrowband scale comparable to [b-ITU-T P.862] in conjunction with [b-ITU-T P.862.1]	MOS-LQOn

Figure 1: Modes of POLQA® and their application (from ITU-T P.863)

POLQA® superwideband mode can be applied to narrowband, wideband and superwideband signals. The MOS scores will also reflect the degradation caused by the respective bandwidth limitation.

POLQA® narrowband mode is provided for compatibility with assessment of narrowband telephony and backward compatibility with P.862.1 (PESQ with mapping of PESQ scores to a MOS scale). In all other application cases the superwideband mode of POLQA® should be used.

1.3 Reference Signals

Clean speech “reference” signals should preferably have the following properties:

- at least three seconds of active speech
- at least one second of silence between active speech periods
- no more than 6 seconds of active speech
- total length of test sample including silence should be no more than 12 seconds
- active speech level of -26 dBov
- 16-bit linear PCM encoded
- noise floor < -80dBov (A)
- speech pauses should not be digital zero but contain noise signal < -80dBov(A)

The level in the speech reference files is specified in “dBov” (“dB overload”) which is the level referenced to a full-scale square wave signal. A full-scale sinewave signal has a rms level of -3 dBov.

Usually one reference signal file contains a pair of sentences separated by a short silence.

Reference signals for POLQA® superwideband should be sampled at a rate of 48 kHz and bandwidth-limited to 50 Hz ~ 14 kHz.

Reference signals for POLQA® narrowband should be bandwidth-limited to 50 Hz ~ 3.8 kHz and sampled at a rate of 8 kHz.

For PESQ® narrowband tests according to P.862 and P.862.1 the file must have a sample rate of 8 or 16 kHz. For PESQ® wideband according to P.826.2 the file must have a sample rate of 16 kHz. The specified wave file should contain speech signal with approximately 8-10 seconds length.

The reference signals should have a leading and a trailing silence at least as long as the expected end-to-end delay in the transmission path under test. This allows

temporal alignment of the degraded signal with the reference signal without loosing portions of the speech.

Codecs and other signal processing algorithms as well as the POLQA® and PESQ® algorithms may react differently to different voices. Therefore it is recommended to conduct tests with two female and two male voices and average the results.

Speech samples “English female 1” and “English male 2” of ITU-T recommendation B-ITU-T P.501 fulfill the requirements for POLQA® reference files. They should additionally be filtered to the SWB or NB frequency range, respectively. These filtered files are included with the installer of this application note.

1.4 POLQA® and PESQ® on the R&S® Audio Analyzer UPV

The PESQ® algorithm according to ITU-T P.862 is available on the R&S® Audio analyzer UPV, called herein below “UPV”, as keycode option UPV-K61. POLQA® according to ITU-T P.863 is provided with option UPV-K63. A description of all parameters and results is given in the current manual of the UPV and in the on-screen context help. Detailed application guides are available in application notes 1GA49 and 1MA202.

1.5 POLQA® vs. PESQ®

POLQA® was developed to enhance the range of test factors, coding technologies and applications compared to PESQ®.

Comparison PESQ® - POLQA®		
Test Factors		
Test Factor	**PESQ®**	**POLQA®**
Speech input levels to a codec		X
Transmission channel errors	X	X
Packet loss and packet loss concealment	X	X
Bit rates if a codec has more than one bit-rate mode	X	X
Transcodings	X	X
Acoustic noise in sending environment		X
Effect of varying delay in listening only tests		X
Short-term time warping of audio signal		X
Long-term time warping of audio signal		X
Listening levels between 53 and 78 dB(A) SPL in superwideband mode		X
Packet loss and packet loss concealment with PCM type codecs	X	X
Temporal and amplitude clipping of speech	X	X

Comparison PESQ® - POLQA®		
Test Factors		
Test Factor	**PESQ®**	**POLQA®**
Linear distortions, including bandwidth limitations and spectral shaping ('non-flat frequency responses')		**X**
Frequency response		**X**
Effect of delay in conversational tests		
Talker echo		
Sidetone		
Acoustic noise in receiving environment		

The last four test factors are addressed by neither of both methods.

Comparison PESQ® - POLQA®		
Applications		
Application	**PESQ®**	**POLQA®**
Codec evaluation	X	X
Terminal testing, influence of the acoustical path and the transducer in sending and receiving direction. (NOTE – Acoustical path in receiving direction only for SWB mode.)		X
Bandwidth extensions		X
Live network testing using digital or analogue connection to the network	X	X
Testing of emulated and prototype networks	X	X
UMTS, CDMA, GSM, TETRA, WB-DECT ,VoIP, POTS, PSTN, Video Telephony, Bluetooth	X	X
Voice Activity Detection (VAD), Automatic Gain Control (AGC)		X
Voice Enhancement Devices (VED), Noise Reduction (NR)		X
Discontinuous Transmission (DTX), Comfort Noise Insertion		X
Non-intrusive measurements		
Two-way communications performance		

The last two applications are supported by neither of both methods.

1.6 Signal Levels

Due to an inherent level alignment, the PESQ® algorithm itself is rather insensitive to absolute levels. Despite this fact, the signal level on the transmission path under test may heavily influence the PESQ® result. Overdriving the transmissions path causes degradation by clipping. A low level on the transmission path may cause degradation by noise. In particular in cases where speech codecs, noise suppression and other non-linear signal processing is involved, a reproducible signal level on the transmission path may be prerequisite for reproducible PESQ® results.

The POLQA® algorithm in superwideband mode as defined in ITU-T P.863 rates the absolute listening level. For obtaining a correct rating, a “gain” factor has to be specified, calculated from several gain factors like artificial ear sensitivity and a factor depending on the analyzer input range. If there is not sufficient information for calculating this gain factor, or for the narrowband mode, the level of the degraded signal should be normalized for the POLQA® algorithm. From UPV firmware 3.3.1, the analyzer function “POLQA” offers an “Auto Gain” parameter which can be activated for this purpose.

This application note provides an application program which runs on the Audio Analyzer R&S®UPV or R&S®UPV66 and can be used to calibrate signal levels for the PESQ® and POLQA® measurements. For the R&S® Universal Radio Communication Tester CMU200, called herein below “CMU”, calibration routines are provided which make use of the “Decoder Cal” and “Encoder Cal” functions. “Decoder Cal” outputs a full-scale sinewave signal with a frequency of 1 kHz. “Encoder Cal” loops back the digital samples from the A/D converter output to the D/A converter input.
For loopback measurements and equipment other than the CMU, a so-called “In / Out – Calibration” is provided which determines approximate full-scale input and output levels of the transmission path from the saturation point of the input-output curve.

For Voice over LTE (VoLTE) tests with a VoIP client installed on a PC or on the UPV itself, the “Decoder Cal” and “Encoder Cal” functionality can be realized by auxiliary programs or by appropriate settings in an audio editor.

The application program allows to specify a test signal and the test signal level relative to full-scale of the input of the transmission path. Furthermore it allows to load a prepared setup and enter the generator reference value and analyzer range according to the determined full-scale values.

To achieve a correct spectrum of the speech signal in the sound pressure at the so-called “Mouth Reference Point” (MRP), an equalization of the electric input signal is required. A coarse equalization can be done with an appropriate filter loaded in the Generator function panel of the UPV. The described application program provides means for loading such a filter automatically. A filter file for equalizing the typical average frequency response of the Bruel & Kjaer Head-and-Torso simulator 4128 is included with the files provided.

The microphone in the artificial ear delivers an electric signal which is proportional to the sound pressure at its membrane (“Eardrum Reference Point”, DRP). To obtain a flat frequency response related to a virtual “Ear Reference Point” (ERP) or related to the sound pressure in a diffuse sound field or free field, respectively, appropriate corrections have to be applied which can be automatically loaded as an analyzer filter by the application program. Filters for DRP-ERP correction, free field correction and diffuse field correction of the type 3.3 artificial ear of the head-and-torso simulator are included with the files provided.

2 Using the Application Program

2.1 Installation

Copy the installer “1GA62.msi” to the UPV hard disk, e.g. to “D:\R&S Software”, and start the installer. Follow the instructions on the screen.

The installer creates the program directory “C:\Program Files\Rohde&Schwarz\1GA62” with all required files. Furthermore the installation creates shortcuts on the desktop and in subfolder “R&S UPV Applications” in the program menu.

Upon the first start of the program, a subdirectory “1GA62” will be created in “D:\UPV” which contains all related user data like UPV setups, program settings and files with calibration data.

2.2 User Interface

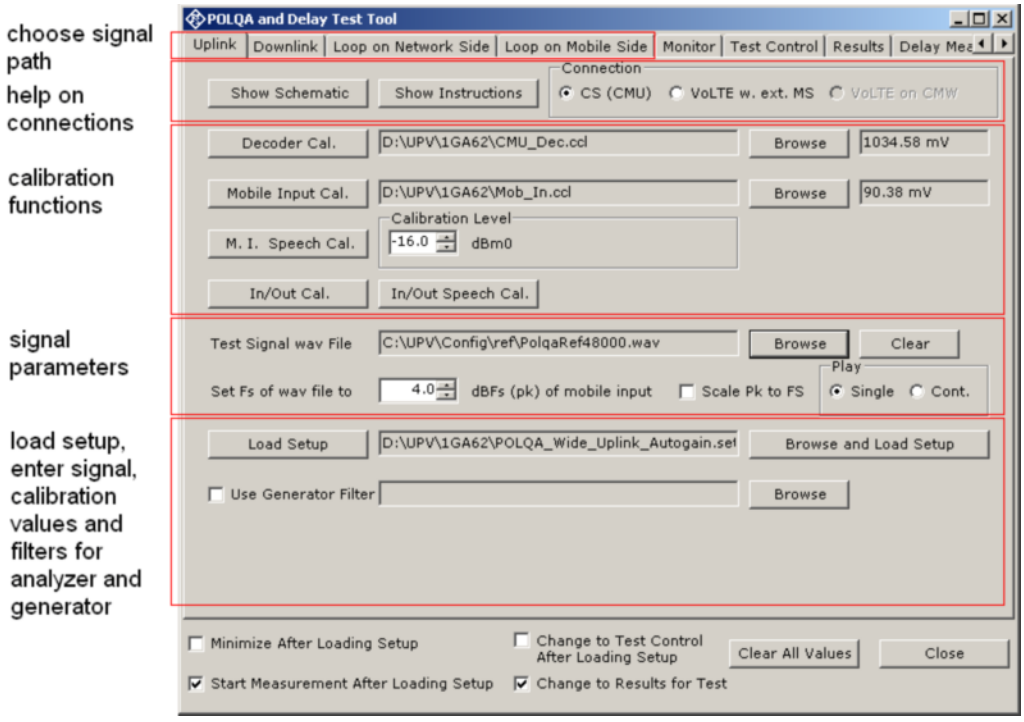


Figure 2: User interface of the application program

The main window of the application program provides nine tabs. The first four tabs are labeled according to the four transmission types “uplink”, “downlink”, “Loopback on Network Side” and “Loopback on Mobile Side”. Each tab provides the appropriate calibration functions for the respective transmission type. In addition there is one tab each for monitor, test control and results, delay measurement and delay results.

Two help buttons on each of the first four tabs give instructions in schematic and in text how to set up the connections. Connection types can be circuit switched with CMU200 and Voice over LTE with CMW500 and external VoLTE client (“Media Server”).

The next section of the user interface provides a row for each required calibration value. The value, if available, is shown on the respective right end. The buttons on the left end start the appropriate calibration routines. In the center a textbox shows the name of the file which stores the current calibration value. Stored values can be loaded using the “Browse” buttons.

Another section follows which allows to specify a wave file to be used as test signal file, and the full-scale value of the wave file relative to the determined full-scale value of the signal path input.

The last section in each tab handles the setup to be used for the test. The text box in the center shows the file name. With the “Load Setup” button, the setup is loaded to the UPV, the generator reference value, signal file name and voltage value are entered and the analyzer range is set appropriately. To load a setup from a file different from the one shown in the text box, use the “Browse and Load Setup” button. For the uplink direction it is possible to load a filter file for speaker equalization. In the downlink tab a filter file for ear correction can be loaded.

The checkboxes below the tabs allow to automatically minimize the window of the application program after the setup has been loaded, and/or to start a (single) measurement immediately afterwards. Two more checkboxes allow to configure to change to the test control tab after a setup has been loaded and to change to the results tab as soon as a test sequence starts.

The user interface of the last six tabs is described with monitor, test automation and reporting functionality further below.

The program memorizes all settings and calibration values in a special file from where they are loaded when the program starts. The button “Clear all Values” can be used to clear the settings and calibration values in all tabs.

2.3 Choosing a signal Path

Besides the traditional transmission directions “uplink” (also called “sending”, seen from the mobile phone’s point of view) and “downlink” (also called “receiving”), the application program also handles setups with loopback of the signal. The loopback may be established on the network side (CMU) or on the mobile side.

In the following section, electrical connections and settings are described for use of the CMU as network interface. Each transmission direction requires an RF connection between CMU and mobile phone.

In other situations other equipment may be connected in a similar matter. Particularly for POLQA in superwideband mode, the electric connections may be replaced by a head-and-torso simulator in case the acoustic performance of the UE should be part of the path to be evaluated, or if no electric connection is possible.

2.3.1 Uplink

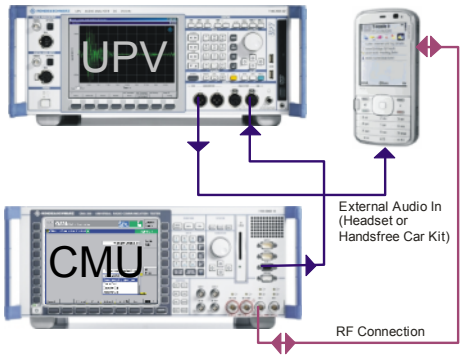


Figure 3: Circuit switched uplink signal path

For circuit switched speech connect:

- UPV generator output 1 to mobile input (headset or handsfree car kit connector)
- CMU speech output to UPV analyzer input 2, using link handler cable 1117.4082.00

Use adapter 1117.4124.00 for link handler 2 if required.

Establish call from the CMU to the mobile.
For the PESQ®, POLQA® and delay measurements set the CMU speech codec to "Handset Low".
For the calibration functions follow the instructions on the screen.

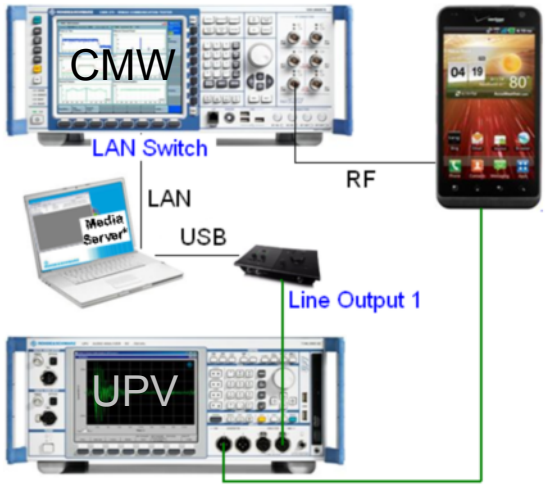


Figure 4: VoLTE uplink signal path

For voice over LTE connect:

- UPV generator output 1 to mobile input (headset or handsfree carkit connector)
- Output 1 of the USB sound card to UPV analyzer input 2.

For the PESQ®, POLQA® and delay measurements establish a VoLTE call between media server and mobile.
For the calibration functions follow the instructions on the screen.

2.3.2 Downlink

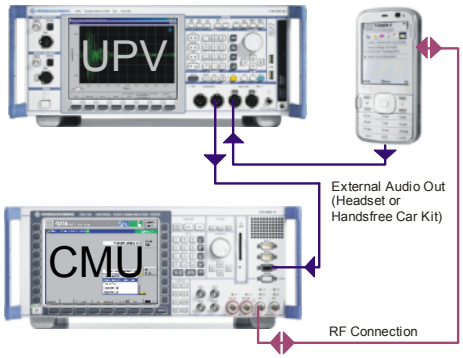


Figure 5: Circuit switched downlink signal path

For circuit switched speech connect:

- UPV generator output 2 to CMU speech input, using link handler cable 1117.4082.00
  Use adapter 1117.4124.00 for link handler 2 if required.
- mobile output (headset or handsfree car kit connector) to UPV analyzer input 1

Establish call from the CMU to the mobile.
For the PESQ®, POLQA® and delay measurements set the speech coder to "Handset Low".
For the calibration functions follow the instructions on the screen.

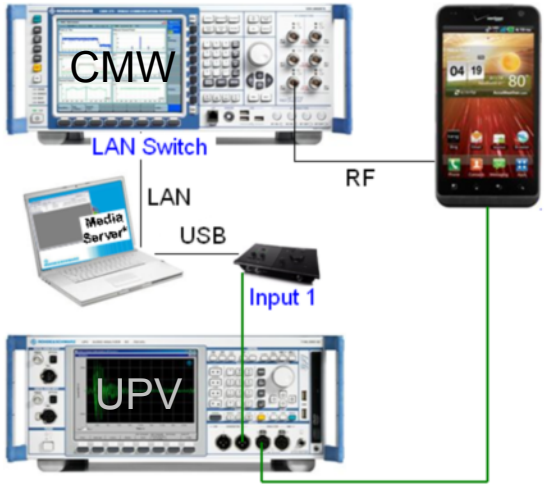


Figure 6: VoLTE downlink signal path

For voice over LTE connect:

- UPV generator output 2 to inputs 1 and 2 of the USB sound card.
- mobile output (headset or handsfree carkit connector) to UPV analyzer input 1

For the PESQ®, POLQA® and delay measurements establish a VoLTE call between media server and mobile.
For the calibration functions follow the instructions on the screen.

2.3.3 Loopback on the Network Side

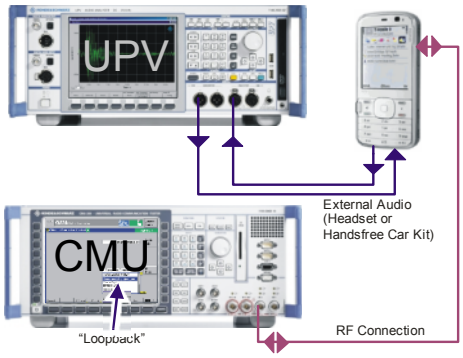


Figure 7: Signal path for circuit switched loopback on the network side

For circuit switched speech connect:

- UPV generator output 1 to mobile input (headset or handsfree car kit connector)
- mobile output (headset or handsfree car kit connector) to UPV analyzer input 1

Establish call from the CMU to the mobile.
For the PESQ®, POLQA® and delay measurements set the speech coder to "Loopback".
For the calibration functions follow the instructions on the screen.

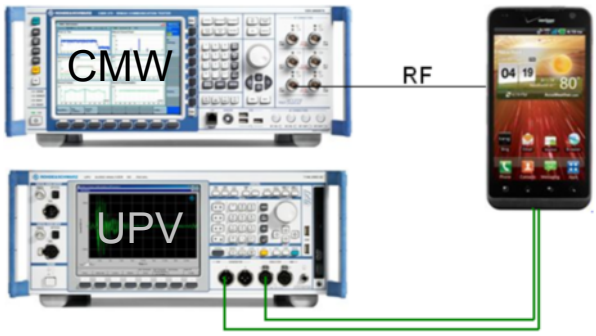


Figure 8: Signal path for loopback on the network side in VoLTE

For voice over LTE connect:

- UPV generator output 1 to mobile input (headset or handsfree carkit connector)
- mobile output (headset or handsfree carkit connector) to UPV analyzer input 1

For the PESQ®, POLQA® and delay measurements establish a VoLTE call in loopback mode.
Make sure that the sidetone on the mobile is disabled.
For the calibration functions follow the instructions on the screen.

2.3.4 Loopback on the Mobile Side

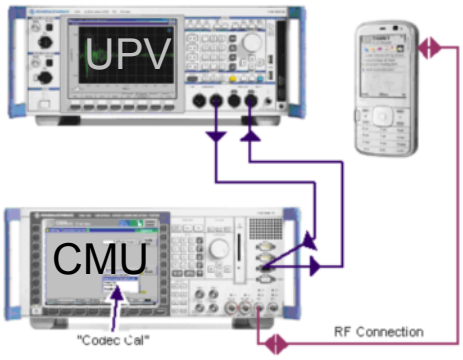


Figure 9: Signal path for loopback on the mobile side in a circuit switched connection

For circuit switched speech connect:

- UPV generator output 2 to CMU speech input, using link handler cable 1117.4082.00
- CMU speech output to UPV analyzer input 2, using link handler cable 1117.4082.00

Use adapter 1117.4124.00 for link handler 2 if required.

Establish call from the CMU to the mobile.
For the PESQ®, POLQA® and delay measurements set the speech coder to "Codec Cal".
For the calibration functions follow the instructions on the screen.

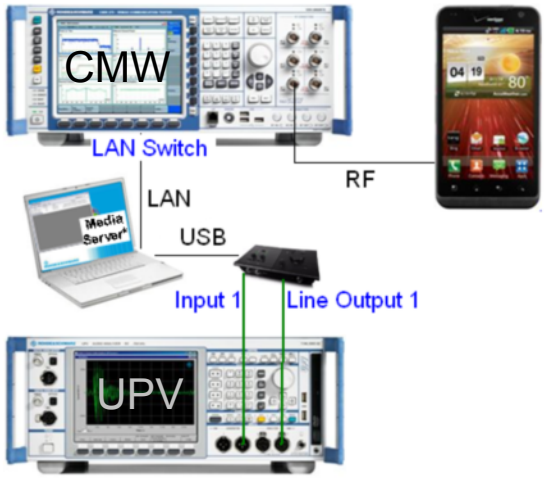


Figure 10: Signal path for loopback on the mobile side in VoLTE

For voice over LTE connect:

- UPV generator output 2 to input 1 and 2 of the USB sound card.
- Output of the USB sound card to UPV analyzer input 2.

For the PESQ®, POLQA® and delay measurements establish a VoLTE call between media server and mobile.
and establish a loopback in the mobile.
For the calibration functions follow the instructions on the screen.

2.3.5 Connection Cable between UPV and CMU Speech Connector

A cable with male (analyzer) and female (generator) XLR connector is required for connection of the UPV to the "Speech" connector of the Digital Radio Communication Tester CMU. The schematic is as shown below:

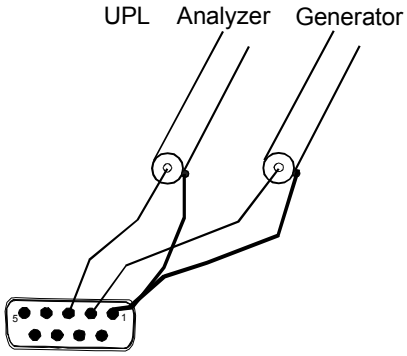


Figure 11: Cable for CMU200 speech connector

Instead of XLR connectors, BNC connectors can be used in connection with UPL-Z1 XLR-to-BNC adapters.

The cable as shown is configured for connection to link handler #1 in the CMU. Depending on the CMU hardware, link handler #2 in the CMU can also be used for GSM; in this case, pin 5 of the DB9 connector has to be connected to the UPV generator instead of pin 2, and pin 6 of the dB connector has to be connected to the UPV analyzer instead of pin 3.

The described cable (part no. 1117.4082.00) and an adapter for link handler #2 (part no. 1117.4124.00) is enclosed in option UPV-K9 (Base SW for mobile phone tests).

2.3.6 Connection Cable between UPV and UE Headset Connector

Cables for connection between UPV and the headset connector of the UE under test are available as option UP-Z9 (part no. 1411.3106.02). The accessory set comprises two cable assemblies: one with ground on the sleeve of the 4-pole 3.5 mm jack plug and one with ground on the second ring of the 4-pole 3.5 mm jack plug.

2.4 Calibration Functions

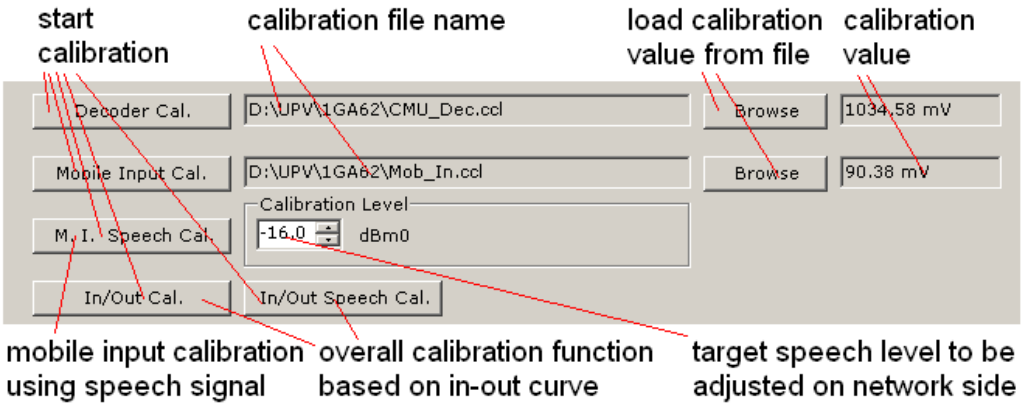


Figure 12: Calibration functions for uplink signal path

For each signal path, the appropriate calibration functions are displayed.

2.4.1 Decoder Calibration

This calibration value is required for uplink measurements, for the encoder calibration and mobile input calibration routines and for measurements with loopback on the mobile side.

For decoder calibration, the application program measures the peak full-scale output of the speech decoder circuit on the network side (CMU), which is connected to UPV analyzer input 2. For a circuit switched connection the CMU must be set to “Decoder Cal” (in GSM “Traffic Mode” on the “Network” tab, in WCDMA “Voice Settings → Voice Source” in the “BS Signal” tab, in CDMA2000 “Primary Service Class → Speech Service → Service Option 3 → Voice Coder” in the “Service Cfg.” Tab). This operation mode requires an active call to the mobile under test. In other setups, the analog output on the network side must be configured to output a full-scale 1 kHz sinewave signal. In a VoLTE setup with external media server, auxiliary program “CsSinWav.exe” must be started while the media server software is idle or closed.

When the “Decoder Cal” button in the application program is clicked, the measurement routine starts. In case of an instable measurement result, a warning message is output, and the routine is aborted without storing the result. If a stable result is obtained, a file selector allows to choose an appropriate location and file name. The working directory “D:\UPV\1GA62” should be the preferred location for these files.

The decoder calibration value is alternatively obtained with the “In / Out Calibration” routines of uplink or loopback on the mobile side. The In/Out calibration requires an end-to-end connection of the type chosen with the respective tab.

In a circuit switched connection, a new decoder calibration is only necessary if the CMU or the link handler in the CMU is changed. In a VoLTE connection with external media server, the decoder calibration has to be re-run if the external soundcard is exchanged or if any hardware or software control settings for the sound car are changed.

2.4.2 Encoder Calibration

This calibration value is required for downlink measurements and for measurements with loopback on the mobile side. A valid decoder calibration value is prerequisite for the calibration routine.

For encoder calibration, the application program adjusts the voltage at output 2 of the UPV generator to the encoder circuit on the network side (CMU) such that the full-scale decoder output voltage is measured at UPV analyzer input 2. For a circuit switched connection, the CMU must be set to “Encoder Cal” (in GSM “Traffic Mode” on the “Network” tab, in WCDMA “Voice Settings → Voice Source” in the “BS Signal” tab, in CDMA2000 “Primary Service Class → Speech Service → Service Option 3 → Voice Coder” in the “Service Cfg.” Tab). This operation mode requires an active call to the mobile under test. In other setups, the analog output on the network side must be configured to loop back the signal from the input to the output with a gain of 1. For a VoLTE setup with external media server, auxiliary program “CsWavRec” must be started while the media server software is idle or closed.

When the “Encoder Cal” button in the application program is clicked, the measurement routine starts and tries to adjust the generator output voltage such that the full-scale decoder output voltage obtained in 2.4.1 is achieved. If the full-scale decoder output voltage cannot be adjusted, a warning message is output, and the routine is aborted without storing the result. If a stable result is obtained, the routine additionally measures the full-scale output voltage from the electric interface of the mobile. File selectors allow to choose appropriate location and file names for both result values. The working directory “D:\UPV\1GA62” should be the preferred location for these files.

The encoder calibration value is alternatively obtained with the “In / Out Calibration” routines of downlink or loopback on the mobile side. The In/Out calibration requires an end-to-end connection of the type chosen with the respective tab.

In a circuit switched connection, a new encoder calibration is only necessary if the CMU or the link handler in the CMU is changed. In a VoLTE connection with external media server, the encoder calibration has to be re-run if the external soundcard is exchanged or if any hardware or software control settings for the sound car are changed.

2.4.3 Mobile Input Calibration

This calibration value is required for uplink measurements and for measurements with loopback on the network side. A valid decoder calibration value is prerequisite for the calibration routine. Prerequisite for the mobile input calibration is an active end-to-end speech connection.

For mobile input calibration, the application program adjusts the voltage at UPV generator output 1 to the mobile under test such that a certain decoder output voltage is measured at UPV analyzer input 2. The CMU must be set to “Handset Low” in GSM (“Traffic Mode” on the “Network” tab), to “Speechcodec Low” in WCDMA (“Voice Settings → Voice Source” in the “BS Signal” tab) and to “8k Enhanced (Low)” in CDMA2000 (“Primary Service Class → Speech Service → Service Option 3 → Voice Coder” in the “Service Cfg.” Tab), respectively. This operation mode requires an active call to the mobile under test. In other setups, the analog output on the network side must be configured to provide a signal connection from the mobile under test to the network output.

The RMS level sent from UPV generator output 1 to the mobile input is adjusted such that the CMU decoder output connected to UPV analyzer input 2 corresponds to the dBm0 level selected in the “Calibration Level” field. The standard speech level is -16 dBm0. However, some mobiles with low sending sensitivity or with dynamic compression algorithms do not allow to reach this level. In this case the calibration level of -26 dBm0 can be used. This level is expected to be within the linear operating range of the uplink path.

The mobile input calibration has to be done for each individual mobile, if codec settings are changed or if settings in a mobile affecting the uplink signal path are changed.

2.4.3.1 Mobile Input Cal.

When the “Mobile Input Cal” button in the application program is clicked, the measurement routine for mobile input level calibration with a sine burst signal starts. If the decoder output voltage corresponding to the selected calibration level cannot be adjusted, a warning message is output, and the routine is aborted without storing the result. If a stable result is obtained, a file selector allows to choose an appropriate location and file name for the result value. The working directory “D:\UPV\1GA62” should be the preferred location for these files.

Mobile input calibration with sine burst signal is only applicable if the end-to-end delay is between 50 ms and 260 ms. As a default, “mobile input speech calibration” should be used, see 2.4.3.2.

The mobile input calibration value is alternatively obtained with the “In / Out Calibration” routines of downlink or loopback on the mobile side.

2.4.3.2 M. I. Speech Cal.

For codecs which do not transmit a sinewave signal with sufficient fidelity, and for end-to-end delays below 50 ms and above 260 ms, this button provides a calibration method using natural speech.

2.4.4 Mobile Output Calibration

This calibration value is required for downlink measurements and for measurements with loopback on the network side. A valid encoder calibration value is prerequisite for the calibration routine. Another prerequisite for the mobile output calibration is an active end-to-end speech connection.

When the “Mobile Output Cal” button in the application program is clicked, the UPV generator sends a speech signal and measures the peak output voltage of the mobile. This value can later be used to set the fix analyzer range for the measurements.

The mobile output calibration has to be run for each individual mobile, if codec settings are changed, the user volume control is changed or if any other settings in the mobile affecting the downlink signal path are changed.

2.4.5 In / Out Calibration

For each transmission direction, an “In / Out Calibration” routine is offered for the case that the network interface is not accessible (loopback on the network side), or does not provide the “Encoder Cal” and “Decoder Cal” routines.

In the case of uplink or loopback on the network side, the input of the transmission path in the electric input of the mobile under test, connected to UPV generator output 1. In case of downlink and loopback on the mobile side, the input of the transmission path is the speech coder input on the network side (CMU), connected to UPV generator output 2.

In case of uplink or loopback on the mobile side, the output of the transmission path is the speech decoder output on the network side (CMU), connected to UPV analyzer input 2. In case of downlink or loopback on the network side, the output of the transmission path is the electric output of the mobile under test, connected to UPV analyzer input 1.

The “In / Out Cal.” Button starts the calibration routine. A pulsed 1 kHz tone is swept in amplitude, starting from a high voltage which is gradually decreased. In an ideal case, the curve of output level (logarithmic scale of the output voltage) over input level exhibits an almost horizontal branch at high levels due to the saturation of the transmission path an a diagonally rising branch at medium levels. Full-scale input and output voltage can be determined from the intersection point of the asymptotes of both branches.

Caution: Make sure that the input of the transmission path (e.g. mobile headset input or loudspeaker with power amplifier) is not damaged by the maximum UPV generator output voltage of 10dBV rms with sine burst and 10 V peak with speech signal. Do not use this function if you are not sure that the device is robust enough.

If the calibration routine is successful, file selectors allow to choose appropriate location and file names for both result values. The working directory “D:\UPV\1GA62” should be the preferred location for these files.

Also the In / Out calibration is provided in two versions: with pulsed sinewave and with natural speech as test signal.

2.4.6 Loading Calibration Values from File

The “Browse” button in each calibration line allows to load previously stored calibration values for each calibration type. The file name of the loaded value is entered in the text box in the center of the line. If the application program is ended, all calibration values and file names are stored in a file and reloaded at the next start of the application program.

2.5 Loading a Setup and Starting a Measurement in Manual Mode

2.5.1 Configuring the Test Signal

The application program allows to specify an appropriate wave (*.wav) file as test signal for the PESQ® or POLQA® test. For requirements on the test signals, see section 1.3.

The test signal file can be selected after clicking the “browse” button in the respective line. The name of the selected file is entered in the text box in the center of the line. If no file name is specified (empty string in the text box), no wave file is loaded to the UPV setup which means that the wave file specified in the loaded setup will be used. The textbox can be cleared using the “Clear” button on the right end of the line.

The full-scale level of the test signal relative to the full-scale level at the input of the transmission path under test is specified in the numeric up/down control in the next line of the user interface. If the full-scale value is not reached in the wave file, the specified full-scale value will not be reached at the UPV generator output. The signal from the wave file can be maximized in the UPV generator after loading by activating the checkbox “Scale Pk to FS”. As different files usually have different crest factor, “Scale Pk to FS” does not mean that the rms level or active speech level at the generator output is normalized.

The level in the speech reference files is specified in “dBov” (“dB overload”) which is the level referenced to a full-scale square wave signal. A full-scale sinewave signal has a rms level of -3 dBov. The level at the speech encoder is either specified in dBFS (referenced to the rms level of a full-scale sinewave) or in digital “dBm0” with

0 dBm0 = -3.14 dBFS.

It is recommended to use speech files which have an internal active speech level of -26dBov = -23 dBFS. To reach the nominal level of -16 dBm0 = -19.14 dBFS in the encoder, the full-scale level of these test signals relative to full-scale of the encoder input or mobile input, respectively, should be set to 4 dB with “Scale Peak to FS” deactivated.

If the test signal has a high crest factor, a full-scale generator output voltage higher than the full-scale input voltage of the transmission path under test (i.e. positive level difference in the numeric up/down control) may be required for optimal PESQ® or POLQA® result. In this case the positive effect of the higher average level has more influence than the potentially detrimental effect of temporal clipping at the signal peaks.

In the “Play” group box, the play mode for the test signal can be switched between “Single” and “Continuous”. Continuous playback of the test signal keeps the speech path in an activated state. When a test is started, the UPV generator is reset and starts with the beginning of the file. When a significant speech delay is present, the end of the truncated speech can appear at the start of the degraded signal. To avoid this effect, switch the “Play” mode to “Single”.

2.5.2 Choosing an equalizer filter

For uplink and for loopback on the network side a filter can be loaded to the generator for approximate equalization of a speaker response, e.g. in case an artificial mouth is used to send the signal to the microphone of the mobile under test. Note that the mobile input (speech) calibration has to be re-run when the downlink setting has been changed.

For downlink and for loopback on the network side another filter can be loaded to the analyzer for DRP-ERP correction of an artificial ear or for diffuse field or free field equalization of a head-and-torso simulator (HATS).

Click the associated “Browse” button to specify the desired filter file, which will automatically be loaded after a setup has been loaded. In folder “D:\UPV\1GA62” some equalization filters are provided for the HATS. “4128C.npz” provides an equalization for the average mouth frequency response of HATS type 4128C. “33_DIFF.npz” and “33_ERP.npz” provide the standard diffuse field equalization and DRP to ERP correction for the type 3.3 artificial ear.

Note that the mobile output calibration has to be re-run when the downlink setting has been changed.

2.5.3 Options to be Carried out after Loading the Setup

The application program can be configured to minimize the window of its user interface after loading a setup (“Minimize After Loading Setup”). This allows to control and watch the UPV window with the result displays.

If preferred, a single measurement can be started immediately after loading a setup (“Start Measurement After Loading Setup”).

Alternatively the tab control in the user interface can change to the “Test Control” tab after loading a setup.

2.5.4 Loading a Setup

The button “Browse and Load Setup” in the tab area opens a file selector which allows to specify a UPV setup for the respective signal path. For each of the four types, various example setups are present in subfolder “D:\UPV\ 1GA62”.

After selecting an appropriate file, the name is entered in the text box in the center of the line and the setup is loaded to the UPV. Thereafter, the relevant calibration value of the respective input of the transmission path is entered as generator reference voltage, the specified wave file is loaded to the “Play” function of the generator and the specified relative peak voltage is set in “dBr” units. The analyzer range is set to accommodate the maximum output voltage of the transmission path under test as specified in the relevant calibration value.

Attention: After changes in the calibration values, in the specification of the test signal and/or in the selection of a filter to be applied, the UPV setup specified in the text box has to be re-loaded using the “Load Setup” button.

2.6 Using the Monitor function

The “Monitor” tab can be used to listen to the speech signal in the current connection, using the built-in loudspeaker of the UPV or a headset connected to the headset jack on the front panel.

Before the monitor is switched on, an appropriate setup with appropriate signal file has to be loaded, using one of the first four tabs.

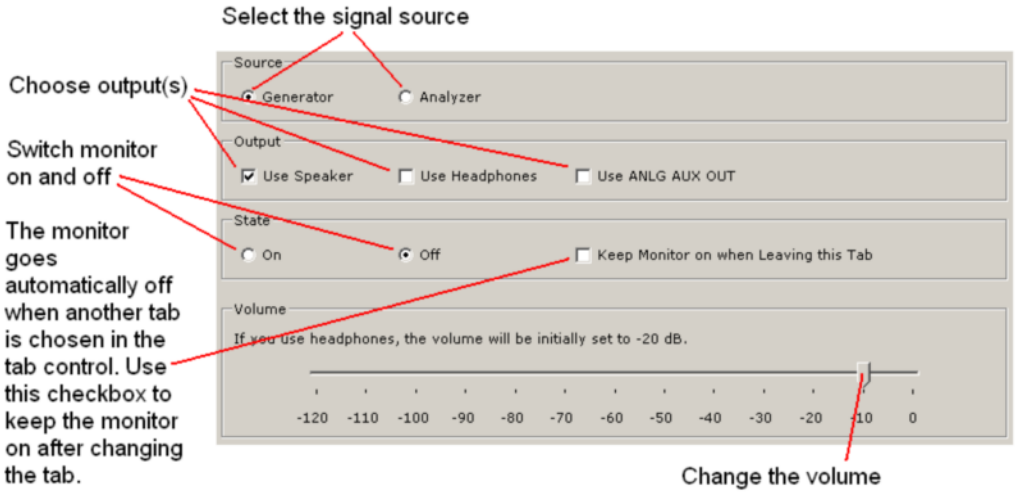

Select the signal source
Choose output(s)
Switch monitor on and off
The monitor goes automatically off when another tab is chosen in the tab control. Use this checkbox to keep the monitor on after changing the tab.
Source
Generator
Analyzer
Output
Use Speaker
Use Headphones
Use ANLG AUX OUT
State
On
Off
Keep Monitor on when Leaving this Tab
Volume
If you use headphones, the volume will be initially set to -20 dB.
-120 -110 -100 -90 -80 -70 -60 -50 -40 -30 -20 -10 0
Change the volume

Figure 13: Controls in the Monitor tab

When the headphone output is enabled and the volume setting is higher than -20 dB, the volume is automatically reduced to -20 dB to protect the listener’s ears. The volume can subsequently be re-adjusted also to higher values. When another tab in the tab control is selected, the monitor output is disabled unless the “Keep Monitor on when Leaving this Tab” checkbox is checked. In the latter case the speaker remains active even if a new setup is loaded or automatic tests are started. The controls in the “Monitor” tab are disabled while automated tests are running.

2.7 Running POLQA® or PESQ® Tests Automatically

2.7.1 User Interface of the Test Automation Tab

The “Test Control” tab provides all controls necessary to set up and run POLQA® and PESQ® test sequences.

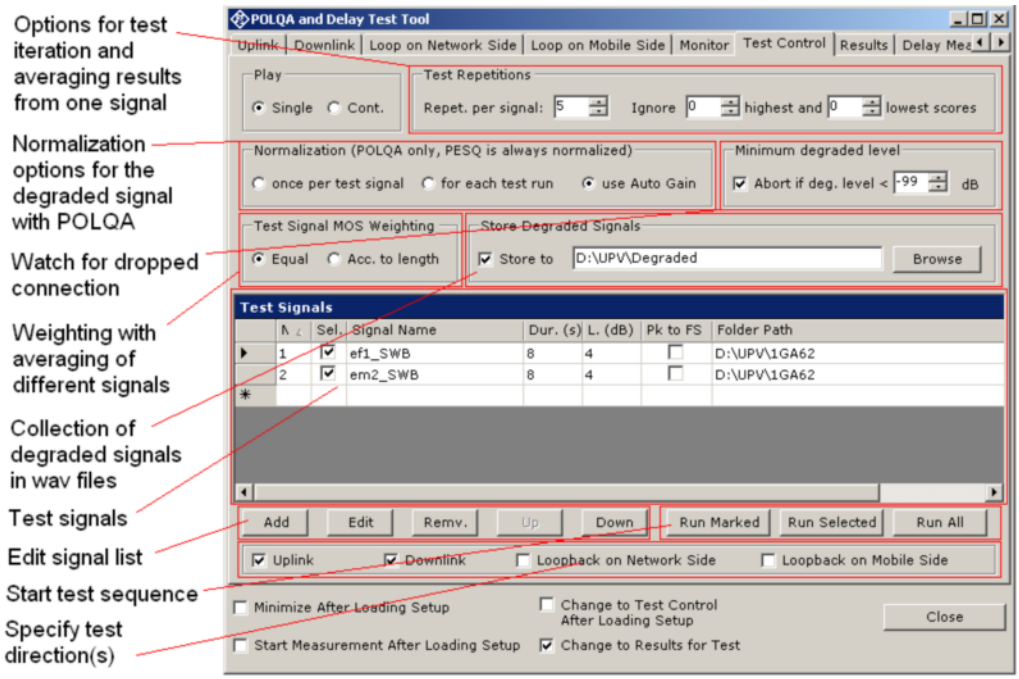


Figure 14: User interface of the "Test Control" tab

2.7.2 Compiling a List of Test Signals

The data grid in the center of the tab shows the compilation of test signals with which the tests are to be run.

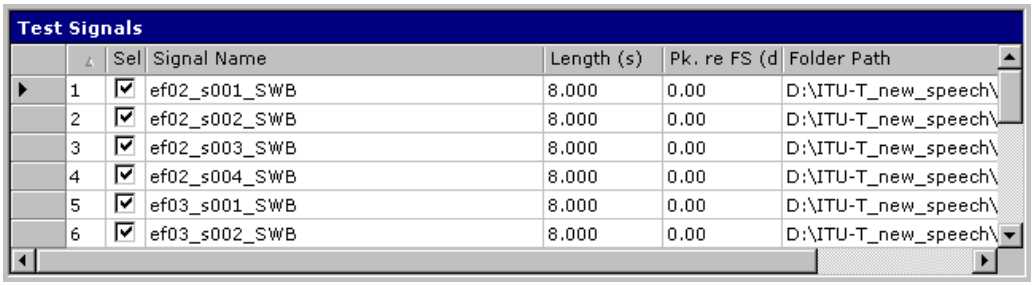


Figure 15:List of test signals

The context menu of the test signal list provides the following entries:

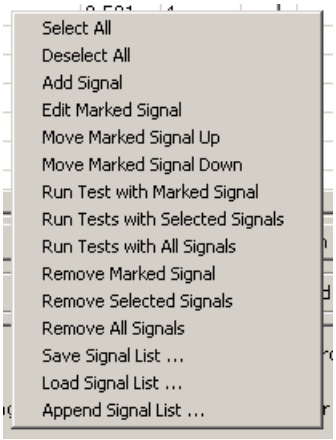


Figure 16:Context menu of test signal list

The list can be edited using the buttons below the left half of the grid or with the respective entries in the context menu. The “Add” and “Edit” buttons open an entry window where the source file and the relative level can be set:

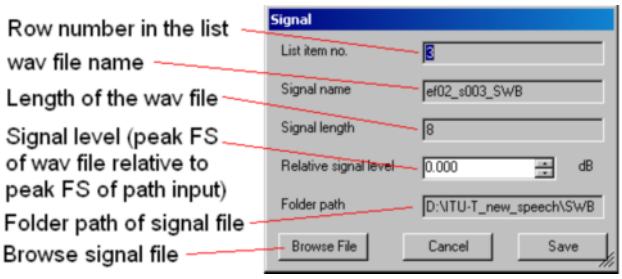


Figure 17: Entry window for editing test signals or adding test signals to the list

To add a signal to the list, click the “Add” button in the Test Control tab, click the “Browse File” button in the signal window and browse to the desired speech signal file. The relative signal level is preset with the value from the first four tabs of the main window. It can be adjusted individually for each signal.

Figure 18: Buttons for modifying the signal list

With the buttons “Edit”, “Remv.”, Up and Down, entries in the signal list and their order in the list can be modified.

A subset of the signal files in the list can be selected for use with the checkboxes in the “Sel.” Column.

Test signal lists can be saved, loaded and appended using the respective entries in the context menu of the test signal list.

2.7.3 Test and Averaging Options

Figure 19: Test repetitions group box in the test control tab

Each signal can be applied multiple times as specified in the “Test Repetitions” group box. Erroneously extreme results can be excluded from averaging. However, all results will appear in the detailed results list and taken into account for the minimum and maximum result values in the overview.

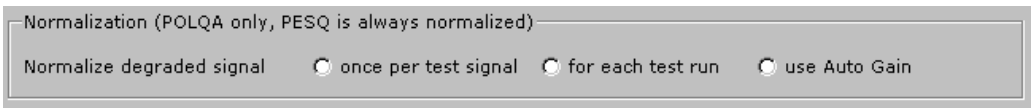

Normalization (POLQA only, PESQ is always normalized)
Normalize degraded signal
once per test signal
for each test run
use Auto Gain

Figure 20: POLQA® normalization group box in the test control tab

As POLQA® as standardized in ITU-T P.863 does not apply automatic level normalization of the degraded signal, additional normalization should be applied unless a meaningful “Gain” value calculated from all involved external gains is available and can be entered in the Analyzer function panel. Normalization can be done once per test signal keeping the “Gain” value determined in the first test run for the subsequent tests with the same signal. Another option is to repeat the normalization for each test run which may increase test time. From UPV firmware 3.3.1, analyzer function “POLQA” offers an “Auto Gain” feature which does the level normalization for each test run in the analyzer. This way, a repetition of the test with changed gain value is not necessary.

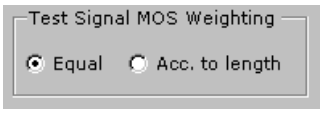


Figure 21: Weighting group box in the test control tab

The results from all test runs on the same signal are averaged with the possible exclusions specified in the “Test Repetitions” field. For each sequence run, a total average is calculated from the averaged per-test-signal results. This averaging over all applied test signals can be done with equal weight or weighted according to the respective length of the test signal files. These options can be chosen in the “Test Signal MOS Weighting” group box.

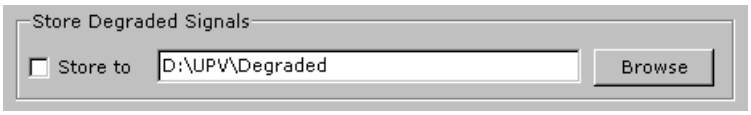


Figure 22: Folder for degraded signals in the test control tab

Degraded test signals can be collected in a specified folder for subsequent analysis of degradation. The folder is specified in the “Store Degraded Signals” group box. The wav file names are automatically generated from the test file name and a number extension. Each degraded file name will appear in the detailed results list to unambiguously assign the degraded signal file to each result.

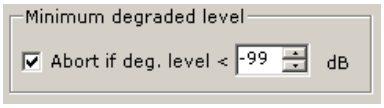


Figure 23: Minimum degraded level groupbox in the test control tab

The “Minimum Degraded Level” group box allows to set a threshold for the degraded level. If the associated checkbox is activated, a running test sequence is aborted when this limit is violated. This allows to automatically react to a lost speech connection.

2.7.4 Starting a Test Sequence

Figure 24: Direction group box in the test control tab

Before starting a test sequence, the desired test direction(s) should be selected in the group box below the start buttons. Thus it is possible to run e.g. uplink and downlink tests in one sequence.

If no direction is selected before the start of a test sequence, it is assumed that all tests are to be run with a setup that has been loaded to the UPV firmware either manually or using the functionality of the first four tabs in this program. A confirmation for this is prompted before the sequence starts.

For each selected direction, the setup specified in the respective tab of the user interface is automatically loaded. However, test signals and levels are set according to the test signal list in the “Test Control” tab.

2.8 POLQA® and PESQ® Test Results

The last tab in the user interface is dedicated to viewing, reporting, exporting and managing results.

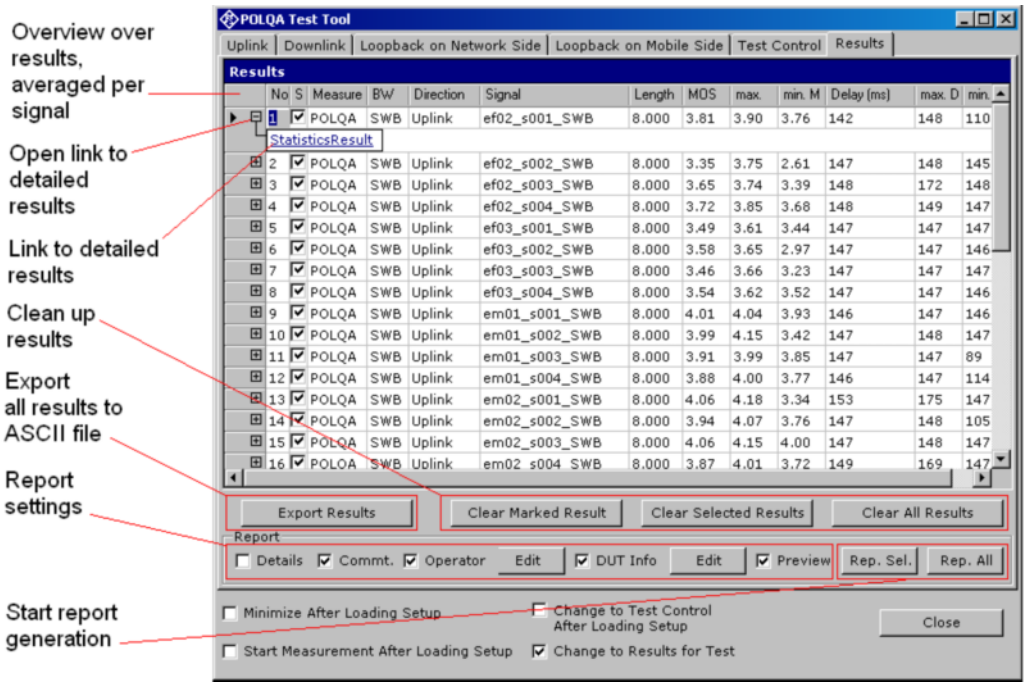


Figure 25: Results tab

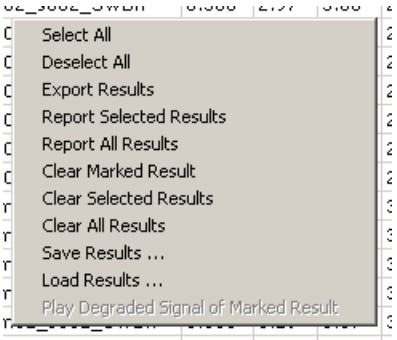
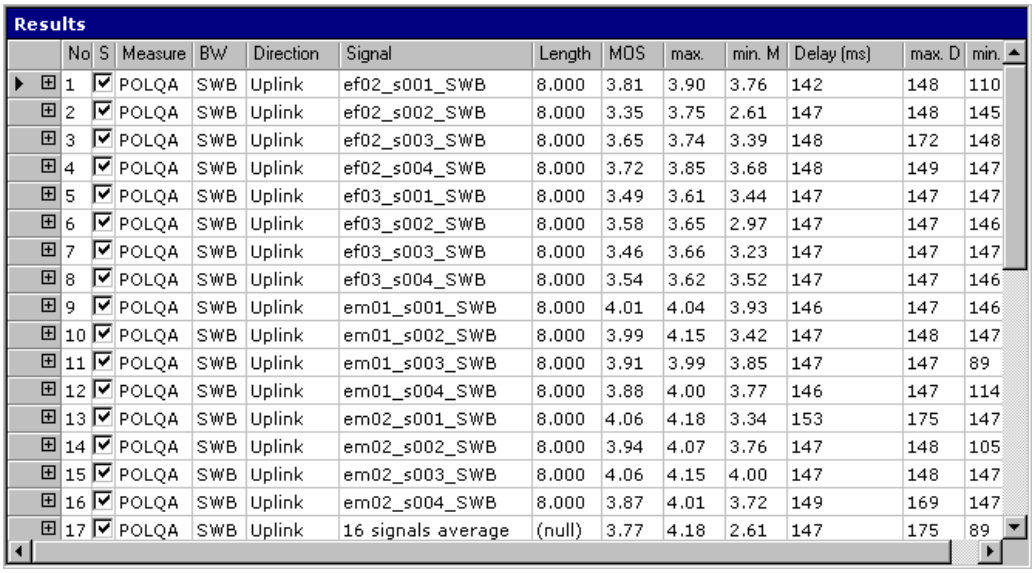


Figure 26: Context menu of the results datagrid

The context menu can be used for reporting and deleting results, and for saving and loading result lists.

2.8.1 Viewing Results in the Data Grid

Initially the data grid shows the averages for each test signal per sequence run.

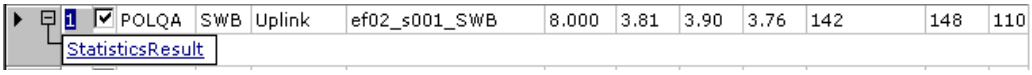


Results

	No	S	Measure	BW	Direction	Signal	Length	MOS	max.	min. M	Delay (ms)	max. D	min.
▶ ⊞	1	☑	POLQA	SWB	Uplink	ef02_s001_SWB	8.000	3.81	3.90	3.76	142	148	110
⊞	2	☑	POLQA	SWB	Uplink	ef02_s002_SWB	8.000	3.35	3.75	2.61	147	148	145
⊞	3	☑	POLQA	SWB	Uplink	ef02_s003_SWB	8.000	3.65	3.74	3.39	148	172	148
⊞	4	☑	POLQA	SWB	Uplink	ef02_s004_SWB	8.000	3.72	3.85	3.68	148	149	147
⊞	5	☑	POLQA	SWB	Uplink	ef03_s001_SWB	8.000	3.49	3.61	3.44	147	147	147
⊞	6	☑	POLQA	SWB	Uplink	ef03_s002_SWB	8.000	3.58	3.65	2.97	147	147	146
⊞	7	☑	POLQA	SWB	Uplink	ef03_s003_SWB	8.000	3.46	3.66	3.23	147	147	147
⊞	8	☑	POLQA	SWB	Uplink	ef03_s004_SWB	8.000	3.54	3.62	3.52	147	147	146
⊞	9	☑	POLQA	SWB	Uplink	em01_s001_SWB	8.000	4.01	4.04	3.93	146	147	146
⊞	10	☑	POLQA	SWB	Uplink	em01_s002_SWB	8.000	3.99	4.15	3.42	147	148	147
⊞	11	☑	POLQA	SWB	Uplink	em01_s003_SWB	8.000	3.91	3.99	3.85	147	147	89
⊞	12	☑	POLQA	SWB	Uplink	em01_s004_SWB	8.000	3.88	4.00	3.77	146	147	114
⊞	13	☑	POLQA	SWB	Uplink	em02_s001_SWB	8.000	4.06	4.18	3.34	153	175	147
⊞	14	☑	POLQA	SWB	Uplink	em02_s002_SWB	8.000	3.94	4.07	3.76	147	148	105
⊞	15	☑	POLQA	SWB	Uplink	em02_s003_SWB	8.000	4.06	4.15	4.00	147	148	147
⊞	16	☑	POLQA	SWB	Uplink	em02_s004_SWB	8.000	3.87	4.01	3.72	149	169	147
⊞	17	☑	POLQA	SWB	Uplink	16 signals average	(null)	3.77	4.18	2.61	147	175	89

Figure 27: Overview over averaged results in the results data grid

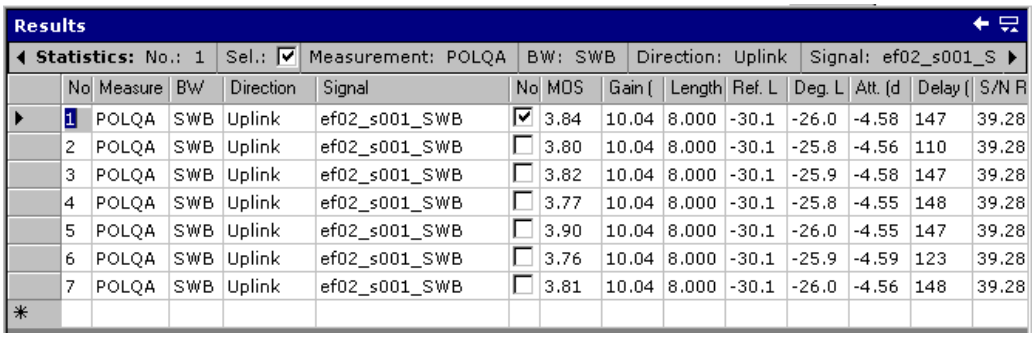
Clicking on one of the small “+” signs in the row headers opens a new row with a link to another table showing the detailed results from which the respective row was averaged:



▶ ⊟	1	☑	POLQA	SWB	Uplink	ef02_s001_SWB	8.000	3.81	3.90	3.76	142	148	110
	StatisticsResult												

Figure 28: Link to detailed results in the results data grid

Clicking on the link displays the detailed data:



Results

Statistics: No.: 1 | Sel.: ☑ | Measurement: POLQA | BW: SWB | Direction: Uplink | Signal: ef02_s001_S

	No	Measure	BW	Direction	Signal	No	MOS	Gain (	Length	Ref. L	Deg. L	Att. (d	Delay (	S/N R
▶	1	POLQA	SWB	Uplink	ef02_s001_SWB	☑	3.84	10.04	8.000	-30.1	-26.0	-4.58	147	39.28
	2	POLQA	SWB	Uplink	ef02_s001_SWB	☐	3.80	10.04	8.000	-30.1	-25.8	-4.56	110	39.28
	3	POLQA	SWB	Uplink	ef02_s001_SWB	☐	3.82	10.04	8.000	-30.1	-25.9	-4.58	147	39.28
	4	POLQA	SWB	Uplink	ef02_s001_SWB	☐	3.77	10.04	8.000	-30.1	-25.8	-4.55	148	39.28
	5	POLQA	SWB	Uplink	ef02_s001_SWB	☐	3.90	10.04	8.000	-30.1	-26.0	-4.55	147	39.28
	6	POLQA	SWB	Uplink	ef02_s001_SWB	☐	3.76	10.04	8.000	-30.1	-25.9	-4.59	123	39.28
	7	POLQA	SWB	Uplink	ef02_s001_SWB	☐	3.81	10.04	8.000	-30.1	-26.0	-4.56	148	39.28
✳														

Figure 29: Detailed results table in the results data grid

The white back arrow “ ← “ in the caption is the link for closing the detailed table and returning to the statistic overview table.

In the details view, the entry “Play Degraded Signal of Marked Result” is enabled in the context menu of the results data grid if the degraded signal is available in a wav file. When this functionality is chosen, a window for controlling the playback of the degraded signal opens:

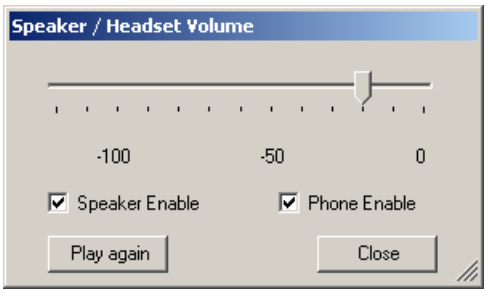


Figure 30: Control window for playback of degraded signals

The window allows to choose the output and set the volume. The file is played once. Then the playback can be restarted using the “Play again” button.

2.8.2 Entering Auxiliary Data

In the “Report” group box, data to be included into the printed report can be administered:

Figure 31: Report group box in the results tab

The “Details” checkbox decides whether tables with the detailed results are included into the printed report. In this case the statistic results will be separated row by row, each with the associated detailed results table below.

If the “Commt.” Checkbox is activated, a comment will be included into the report. An entry window will pop up when the report is started.

The “Operator” checkbox specifies whether an operator’s name is to be included into the printed report. For entering a name, click the “Edit” button next to the checkbox.

The “DUT” checkbox allows to add information about the device under test. For entering name, type, manufacturer and serial number, click the “Edit” button next to it.

2.8.3 Previewing a Report

For previewing a report in the Windows print preview, activate the “Preview” checkbox before clicking “Rep. Sel.” Or “Rep. All”. The latter button starts preview of all results in the data grid. The “Rep. Sel.” Button starts exclusive preview of results checked in the “S” column of the table. Finally the Windows print preview opens with a preview of the report as configured:

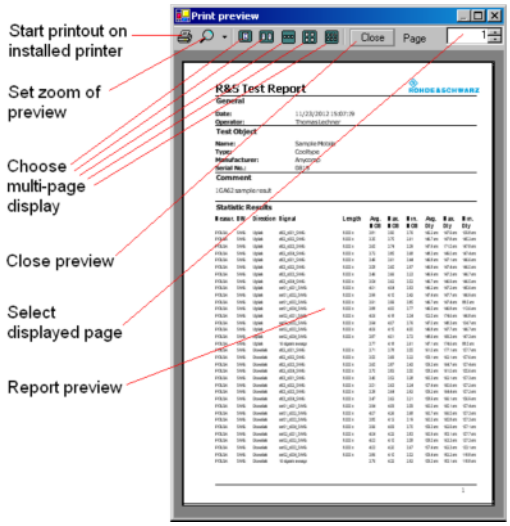


Figure 32: Report preview

2.8.4 Printing a Report

A report can be printed on any printer installed in the Windows operating system, including XPS document writer or pdf distiller.

The printing can either be started from the preview window by clicking the printer icon top left or by clicking one of the “Re. Sel.” or “Rep. All” buttons without the “Preview” checkbox activated.

The printer can only be selected if the latter way of starting the printout is chosen.

2.8.5 Export of Result Data to an ASCII file

The “Export results” button saves all available results to a tab-separated txt file or a comma-separated csv file which can easily be imported to a spreadsheet.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Statistics													
2	No.	Measurem	Bandwidth	Direction	Signal	Length	Avg. MOS	Max. MOS	Min. MOS	Avg. delay	Max. delay	Min. delay	Identifier	
3	1	POLQA	SWB	Mobile Loc	ef02_s001	8.500208	3.908971	3.953615	3.857836	445.5949	464.6147	424.2723	01/14/2013	09:40:45
4	2	POLQA	SWB	Mobile Loc	ef02_s002	8.5	3.945699	4.0004	3.861595	429.8408	450.0769	410.1642	01/14/2013	09:43:56
5	3	POLQA	SWB	Mobile Loc	ef02_s003	8.500021	3.851822	3.923364	3.752919	483.9594	507.8291	462.425	01/14/2013	09:44:59
6	4	POLQA	SWB	Mobile Loc	ef02_s004	8.500021	3.728467	3.766152	3.683336	423.7631	445.2938	401.2763	01/14/2013	09:48:46

Figure 33: Test results imported to a spreadsheet (excerpt)

2.9 Delay Measurements

The “Delay Measurements” tab provides controls for measuring the end-to-end delay of a speech connection.

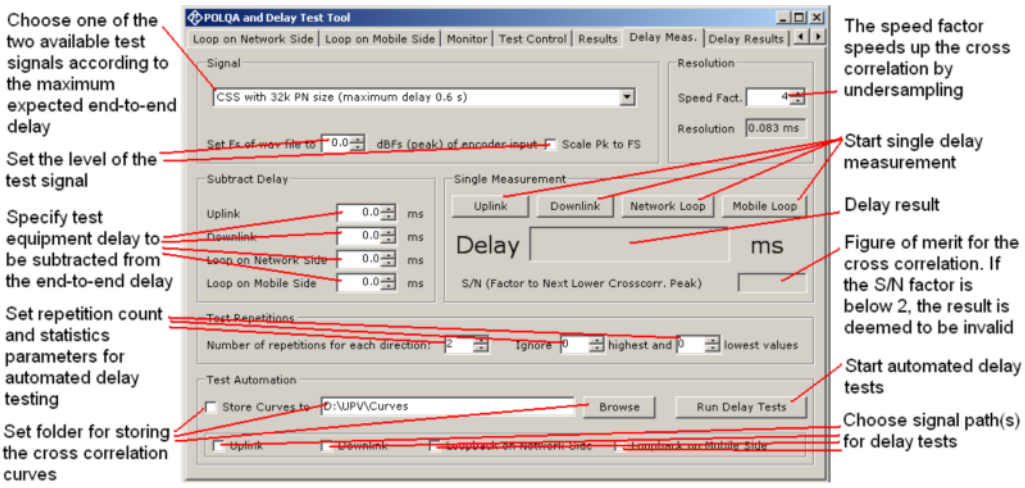


Figure 34: Controls of the delay measurement tab

Delay Measurements are performed on a pseudo-random multisine signal by cross correlation. The test signal further comprises a leading voiced part to activate the speech coder. The length of the pseudorandom part determines the maximum measureable end-to-end delay. With a 32k samples pseudorandom noise, a maximum delay of 0.6 seconds can be measured. With the 46k samples pseudorandom noise, the maximum delay which can be measured is 1.2 seconds. The delay measurement works with an end-to-end delay > 10 ms.

To speed up the cross correlation calculation, the number of samples can be reduced by the “speed factor” by undersampling the test signal before cross correlation. This of course is a tradeoff against time resolution and noise immunity. For the two available test signals, separate speed factors are stored by the program.

In the “Subtract Delay” groupbox it is possible to specify for each of the four signal paths delay values of the system simulator to be subtracted from the end-to-end delay. Note that any processing delay occurring in the UPV itself is inherently subtracted from the results before they are displayed.

The buttons in the “Single Measurement” groupbox start delay measurements for each of the four signal paths and display the result in the textbox below. The S/N factor displayed is the amplitude ratio between the highest cross correlation peak and the second highest cross correlation peak. If this ratio is less than 2, the result is deemed to be invalid. In this case you can reduce the speed factor to improve the noise immunity of the delay measurement.

In the “Test Automation” groupbox it is possible to start multiple delay measurements for each of the selected signal paths and do a statistical evaluation as specified in the “Test Repetitions” groupbox. It is possible to store the cross correlation result as curve in an ASCII file to a specified folder.

2.10 Delay Results

Reporting and handling of delay results is similar to that of the speech quality test results. Please refer to sections 2.8.1. to 2.8.5.

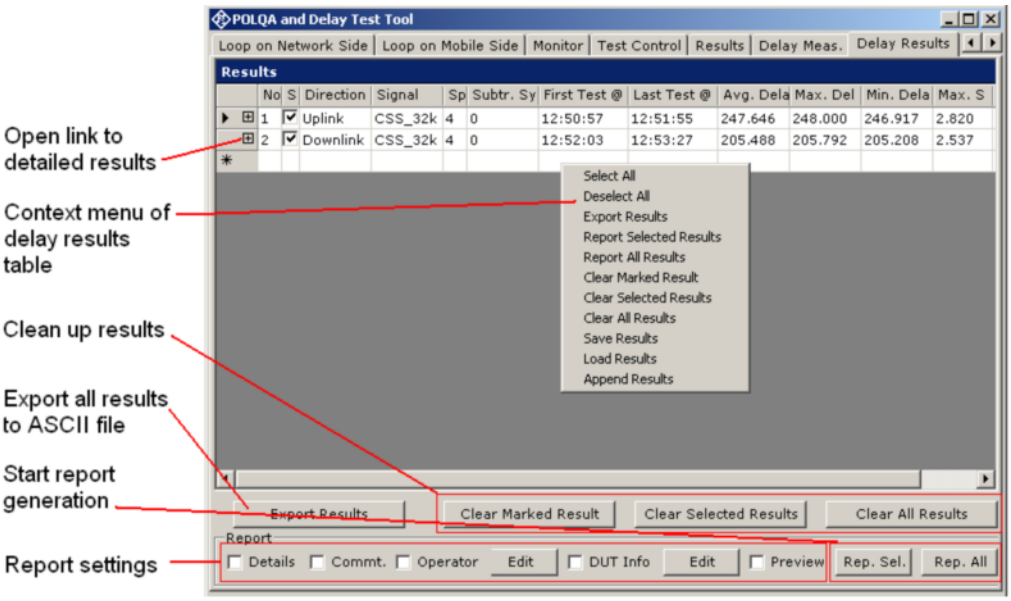


Figure 35: Controls of the delay results tab

3 Literature

- R&S® UPV Operating Manual
  http://www2.rohde-schwarz.com/en/service_and_support/downloads/download_search/
- Application Note 1GA47, “Calibrating Measuring Microphones and Sound Sources for Acoustic Measurements with Audio Analyzer R&S® UPV”
  http://www2.rohde-schwarz.com/en/service_and_support/Downloads/Application_Notes/
- Application Note 1GA49, “Psychoacoustic Audio Quality Measurements Using R&S®UPV Audio Analyzer”
  http://www2.rohde-schwarz.com/en/service_and_support/Downloads/Application_Notes/
- Application Note 1GA50, “Calibration Tool for PESQ® Speech Quality Tests”
  http://www2.rohde-schwarz.com/en/service_and_support/Downloads/Application_Notes/
- Application Note 1MA202, “Next-Generation (3G/4G) Voice Quality Testing with POLQA®”
  http://www2.rohde-schwarz.com/file/1MA202_1e.pdf
- ITU-T P.862 (2001), “Perceptual evaluation of speech quality (PESQ): An objective method for end-to-end speech quality assessment of narrow-band telephone networks and speech codecs”, http://www.itu.int
- ITU-T P.862.1 (2003), “Mapping function for transforming P.862 raw result scores to MOS-LQO”, http://www.itu.int
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- ITU-T P.863 (2011), “Methods for objective and subjective assessment of speech quality - Perceptual objective listening quality assessment”, http://www.itu.int
- User Manual, POLQA OEM Library, Opticom GmbH
- Application Note “Voice Quality with ITU-T P.863 ‘POLQA’”, Swissqual
  http://www.swissqual.com/index.php/pages/downloader/Application_Note_-_Voice_Quality_with_ITU_P.863_POLQA.pdf
- ITU-T Application Guide for P.863 (unpublished draft)

4 Ordering Information

Ordering Information		
Type of instrument		
Description	**Instrument type**	**Ordering number**
Audio Analyzer	R&S®UPV or R&S®UPV66	1146.2003.02 1146.2003.66
XLR/BNC Adapter Set	R&S®UP-Z1MF	1411.3306.02
Headset Cable Set for UPV	R&S®UP-Z9	1411.3106.02
Universal Sequence Controller	R&S®UPV-K1	1401.7009.02
SW for PESQ Measurements	R&S®UPV-K61	1401.7309.02
Listening quality analysis POLQA, to ITU-T rec. P.863	R&S®UPV-K63	1402.1156.02
Universal Radio Communication Tester	R&S®CMU200	1100.0008.02
Wideband Radio Communication Tester	R&S®CMW500	1201.0002K50

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